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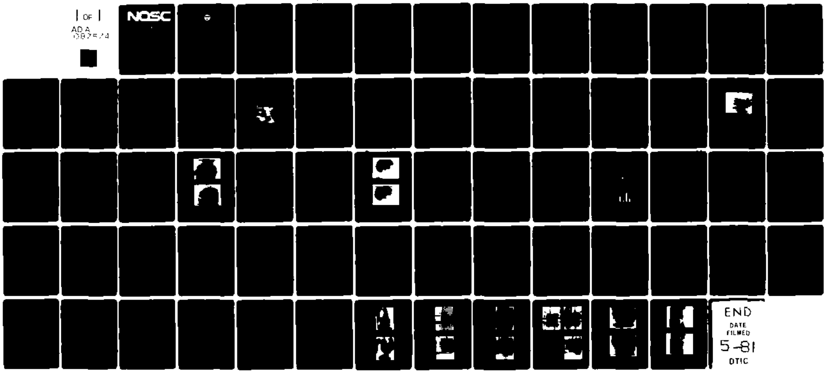

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FEASIBILITY TESTS OF THE REMOTE MEDICAL DIAGNOSIS SYSTEM

January 1975 – May 1976

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I. Stevens

(NOSC)

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(WESTEC Services, Inc.)

January 1981

Prepared for

Naval Medical Research and Development Command

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ADMINISTRATIVE INFORMATION

This Technical Document is one in a series on the Remote Medical Diagnosis System (RMDS), NOSC Work Unit CM38, sponsored by the Naval Medical Research and Development Command. This document contains the results of shipboard feasibility tests performed under an operational assist, CNO Project X/S-66 (CNO ltr. ser. 983D2/68505 dated 6 January 1975). The tests were conducted at NOSC, the Naval Regional Medical Center (NRMC) San Diego, and aboard the USS JUNEAU (LPD-10), USS ALAMO (LSD-33), and USS FORT FISHER (LSD-40), from January 1975 to May 1976.

These feasibility tests were performed by the medical departments at the participating units, the NOSC Bioengineering Branch (Code 5123), and WESTEC Services, Inc. (Contract N00244-76-MCS-88), with coordination by DEPCOMOPTEVFORPAC, San Diego. Principal investigators were W.T. Rasmussen and I. Stevens (NOSC, Code 5123).

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METRIC CONVERSION TABLE

Customary US Unit	Metric Conversion Factor
1.0 inch	2.54 cm
1.0 lb	.45 kg
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Remote Medical Diagnosis System (RMDS) feasibility tests were performed to determine the usefulness and technical requirements of a shipboard system designed to provide assistance in making emergency medical diagnoses aboard ship. This experimental RMDS unit used commercially available equipment. Initial tests were conducted between two land sites, and later operational tests were carried out on three vessels and at two shore stations. The RMDS concept was demonstrated to be feasible. Further system development, using state-of-the-art technology, is recommended.

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OBJECTIVES

Test objectives incorporated in the RMDS feasibility testing included determination of: the relative utility of frame freeze and live operational modes; the diagnostic utility of received video information: the optimum range of field of view sizes; the *feasibility of RMDS use in a cryptographically secure mode*; and the feasibility of RMDS use for audio-video lecture purposes.

CONCLUSIONS

The use of RMDS in an operational environment is a feasible concept and can be a useful aid on ships and at remote shore facilities. Currently designed and available off-the-shelf equipment is not totally adequate for the needs and requirements of a Navy shipboard RMDS. However, the state-of-the-art is such that a system can be designed which will satisfy the requirements and specifications. This system can be designed from existing components with minimal technological development. System capabilities must include voice, slow-scan video, and physiological waveform telemetry in order to provide adequate diagnostic tools.

RECOMMENDATIONS

The results of this testing lead to the following design recommendations: capabilities for analog and digital data transmissions compatible with variable data rate modems; direct transmission of physiological waveforms with interface to a strip chart recorder: frame freeze and direct scanning capabilities: variable control of digital quantification; automatic and manual receive modes; and voice transmission capabilities. Other recommendations for the capabilities of storage, recording, camera, monitor, X-ray light box, and illumination appear in section 6.2.

Further development of the RMDS, using state-of-the-art technology, is recommended in the areas of: spatial and gray level resolution; dynamic range; noise levels; data compression; physiological waveform monitoring instrumentation; simultaneous voice and data transmission; satellite communications; analog/digital system design; and related areas of applied research. These recommendations are detailed in section 6.3.

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SECTION 1

INTRODUCTION

1.1 BACKGROUND

Major types of warships such as aircraft carriers, cruisers, and amphibious command ships normally have a well-staffed Medical Department including one or two physicians and one or two dentists. The aircraft carrier medical staff is supplemented with two to four additional physicians (usually flight surgeons) on temporary assignment when the Carrier Air Wing is onboard.

On smaller types of ships, destroyers for example, this is not the case. Generally only one physician is available for each squadron, possibly rotating among the ships, leaving the other ships medically staffed with independent duty corpsmen who may or may not have been trained as physician's assistants. Often there are occasions on these ships when a corpsman may be uncertain as to a patient's pathological condition, and whether that patient should be evacuated to a major medical center. Currently, when such a situation arises, the corpsman requiring outside assistance uses the ship's radio communication system to contact a physician onboard another ship or at a shore station. To request this assistance the corpsman must leave the sick bay area and go to the ship's communications center. If the physician who is contacted for assistance requires additional information regarding the patient, it may be necessary for the corpsman to leave the communications center (COMMCEN), go back to sick bay, obtain the necessary information, and then return to the COMMCEN to complete the consultation. Past experience has shown that this method of remote diagnosis is not always satisfactory.

In less critical situations the corpsman may initiate a narrative message to the ship or shore station from which help is sought. Such a message is transmitted with "routine" or "priority" precedence and may take from several hours to one or more days for delivery and return. In many cases, this delay may be totally unacceptable. In addition, information copies of all messages must be sent to a number of addressees in both chains of command involved, thus tending to saturate an already overburdened communication system. And just as the corpsman has a need for ship-to-ship and ship-to-shore communication, the shipboard physician must also communicate on important matters relating to patient diagnosis, treatment, and possible evacuation. These needs are not satisfactorily met by existing communication facilities and procedures.

Recognizing these problems, the Naval Ocean Systems Center (NOSC) has, since July 1972, investigated various means of transmitting medical data. These have included the usual Navy communication modes, teletypewriter (TTY) or voice via hf, and full duplex broadband telecommunication of simultaneous video and sound. The investigation has also included review of experimental studies conducted elsewhere on medical data transmission, microwave, and satellite.

It was soon realized that any medical communication system, in order to meet the real requirement, would need to have a visual channel capable of transmitting and displaying graphic and pictorial data. Accordingly, a conceptual basis was developed for a Remote Medical Diagnosis System (RMDS) which had both visual and voice capability, and which would provide ship-to-ship and ship-to-shore links between medical facilities. An experimental version of RMDS was developed using commercially available off-the-shelf equipment interfaced with standard Navy radio communication equipment.

In order to subject the experimental RMDS to an operationally-oriented evaluation, an Operational Assist Project was requested in September 1974 from the Chief of Naval Operations by the Commanding Officer of the Naval Medical Research and Development Command. This request was supported with information supplied by NOSC, including proposed feasibility tests. The Chief, Bureau of Medicine and Surgery (BUMED) endorsed the request, and on 6 January 1975, CNO ltr. ser. 983D2/68505 assigned Project X/S-66 to Commander, Operational Test and Evaluation Force (COMOPTEVFOR) for prosecution. Additionally, CNO requested Commander-in-Chief, U.S. Pacific Fleet to provide such assistance as may be required by COMOPTEVFOR in the prosecution of this project.

BUMED, as the Primary Developing Agency (PDA) for this project, designated NOSC as the lead laboratory and prosecuting agency. COMOPTEVFOR directed Deputy Commander, Operational Test and Evaluation Force, Pacific (DEPCOMOPTEVFORPAC) to assign a project officer to act as liaison officer between the operating forces and NOSC, and to observe selected tests. Additionally, DEPCOMOPTEVFORPAC was responsible for obtaining services from appropriate ships to act as test platforms.

1.2 PURPOSE AND OBJECTIVES

The purpose of this Operational Assist Project was to test the RMDS in an operational environment, determine its feasibility, assess the suitability of its slow-scan video techniques, and determine the types of communication links which would adequately support it. Test objectives incorporated in the test plan included determination of:

A. The relative usefulness of the two modes of operation, frame freeze and live, for shipboard application.

B. The adequacy of received video information for diagnosis by a qualified physician.

C. The most useful range of field of view sizes to be covered by the camera under different operational modes, ie, fixed versus remote (tripod).

D. The feasibility of using the RMDS in a cryptographically secure mode.

SECTION 2

DESCRIPTION OF THE FEASIBILITY TEST SYSTEM

2.1 GENERAL

The experimental RMDS was a half duplex system designed to provide the capability of transmitting and receiving static pictorial information derived from analog television video signals over a voice-bandwidth (3 kHz) dial telephone network. It provided for viewing a subject with a commercially available television camera operating at the normal TV scanning rate, then converting to a much lower rate for transmission, storing the received picture at the slow rate, and then presenting it for display as a still picture on a TV monitor (see figure 1). The experimental RMDS was compatible with closed circuit TV (CCTV), and therefore the diagnostic data could be retransmitted at the receive terminal over a local CCTV system, thereby extending the scope of system participation. Unlike broadcast TV, this system did not present motion in the display; also, the voice channel was suppressed during picture transmissions.

NOSC provided complete equipment suites for all participating ships and stations. The large items of equipment came as parts of the videovoice Half Duplex System, Type VV-1, leased from RCA Global Communications. The videovoice system was selected because it had several advantages:

A. Immediately available off-the-shelf.

B. Facilitated video or voice transmission between terminals, although not simultaneously.

C. Operator and maintenance training was simple.

D. The system was available on a lease basis at reasonable rates.

E. The system was self-contained and posed no significant installation problems for shipboard use.

F. The slow-scan video portion of the system was compatible with the standard 3 kHz single-channel voice circuitry and the Command Switch Board (CSB)* terminals available to all Navy shore stations.

The experimental RMDS could also transmit ECG signals by telephone or radio link, and input them to an ECG machine at the receiving station for plotting (see figure 1). Note that this was independent of the RCA videovoice equipment. A later arrangement, not used during the feasibility tests, did modify the videovoice equipment with special circuitry and switching so that it could be used to transmit and receive either picture material or ECG signals.

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*Formerly Inter-Command Switch Board (ICSB).

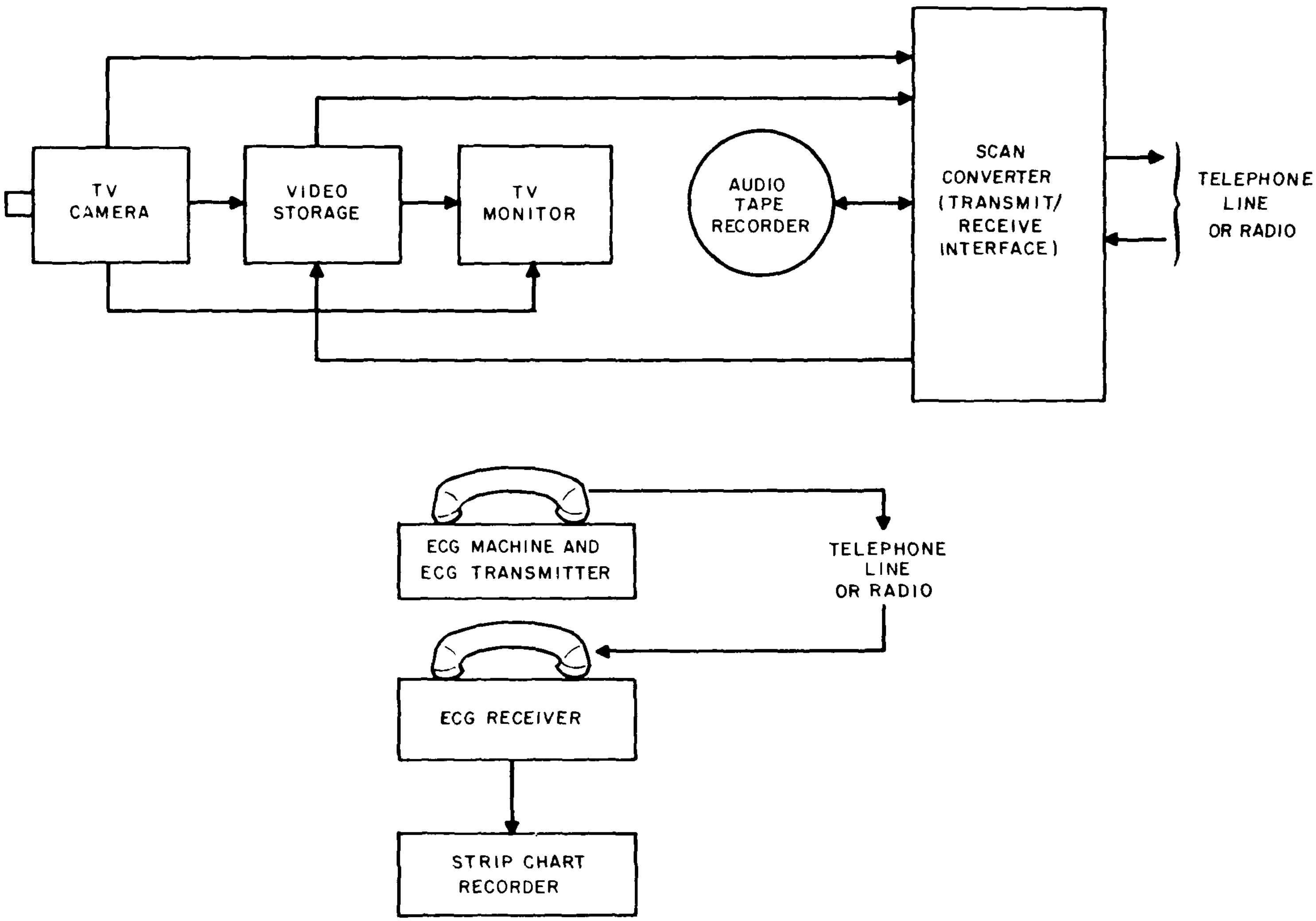


Figure 1. Experimental RMDS station.

2.2 SYSTEM EQUIPMENT

Each RMDS station included a TV camera, a TV monitor, a combination telephone and control unit (TCU), and an electronics package.

Television Camera:

This was nested into the top of the monitor but could be removed and operated from a remote tripod assembly. The camera operated essentially straight ahead with $\pm 5°$ controllable lens angle tilt capability and 360° azimuth swivel capability. Zoom capability was provided by a Vario-Switar 85 lens added to the camera. This lens had a variable focal length from 17 to 85 mm and variable aperture settings from 3.5 to 22. The range control on the lens was set at 1 meter. Focus could be controlled on the camera itself as the user viewed the monitor.

Monitor Assembly:

The monitor assembly was a desk-top/pedestal type, with top-mounted socket to accommodate the camera assembly. The display was a 9-inch CRT with a 4 x 3 aspect ratio. The variable focal length zoom lens could be used to vary the area viewed on the monitor screen from 2 x 2-5/8 inches to 10-1/2 x 14 inches. Audio was provided by means of an integral loudspeaker which permitted hands-free operation. Operating controls were provided with the TCU.

Telephone and Control Unit:

The TCU was a movable unit incorporating the contrast, brightness, and volume controls for the TV monitor assembly. It contained a telephone handset and rocker switch cradle assembly to permit microphone ON-OFF control. The microphone was capable of hands-free, unidirectional operation with a 100 Hz to 10 kHz frequency response (a maximum bandwidth of 3 kHz for transmission was utilized, however) at a -65 dBm input level. Illuminated pushbutton controls were provided, with individual buttons for videovoice, live camera, frame freeze, and transmit. The pushbutton array also included an indicator light for the receive mode.

Electronics Package:

The electronics package was mounted separately from the other three units. It provided power and input/output line regulation, and contained the frame freeze and storage assembly, silicon storage tube, automatic switching circuitry, and crystal oscillator synchronizing circuits. It supplied the standard video raster format and the video signal, either as it came in real time from the camera or repetitively from storage.

Peripheral Devices:

A. A standard dial telephone set equipped with an executive privacy button. Activation of this button transferred the incoming telephone call (or radio phone patch) to the TCU. (This was used at NRMC only.)

B. A light box which provided lighting from underneath for X-ray negatives.

C. A Polaroid Land camera fitted with a special mounting bracket to permit the photographing of incoming or outgoing presentations on the monitor.

D. A two-channel analog tape recorder. This permitted recording of the video as well as the transmitted or received audio data for later playback, if desired, and for record-keeping purposes.

E. Remote camera kit. A tripod dolly assembly upon which the camera was mounted to permit greater freedom of movement in all directions within 25 feet of the system.

F. Equipment table.

2.3 EQUIPMENT INSTALLATION AND MAINTENANCE

A. The physical and electrical characteristics of the experimental RMDS and associated environmental parameters related to installation and maintenance are provided in table 1.

B. NOSC was responsible for installation of the experimental RMDS onboard the project ships, and was assisted by RCA and the Naval Electronics Systems Engineering Center (NESEC), San Diego.

C. Installation costs were approximately $8,500 (1975 dollars) and required about 40 working days of effort.

D. Equipment costs, exclusive of cabling and mounting requirements, are shown in table 2. Note that these cost data were effective during the time of this study, January 1975 through May 1976. Operating manuals were provided with the equipment. Installation instructions were provided under the purchase or lease price of the equipment.

E. Pre-deployment repair of equipment was effected by RCA field engineers.

F. Equipment spares consisting of 100 percent redundancy of key equipment subassemblies were provided prior to deployment to project ships.

G. Maintenance at sea was performed by shipboard technicians, and was accomplished by equipment replacement.

Physical Characteristics	
Electronics Package:	19 in. High x 22 in. Deep x 20 in. Wide; 160 lbs
Camera/Monitor Assy:	14-9/16 in. High x 11 in. Deep x 9-5/8 in. Wide; 40 lbs
Telephone/Control Set:	4 in. High x 8-1/2 in. Deep x 9-1/2 in. Wide; 5 lbs

Electrical Characteristics

1. Input Voltage: 115 Volts ac, single phase, $\pm$15 percent
2. Input Frequency: 50 or 60 Hz + 5 percent each frequency
3. Input Power:
   a. Basic System: 300 watts maximum
   b. Optional Equipment: 200 watts maximum
4. Power Connection: 3-prong flat-bladed ac line plug including grounding pin
5. Input Protection: 5 amp circuit breaker

Environmental Parameters

1. Operating Temperature Range: 20^{o}C to 40^{o}C ambient
2. Operating Humidity: 0 to 95 percent relative humidity

Table 1. Physical and electrical characteristics and environmental parameters.

Terminal	Leased	Purchase Price
Type VV-1 Terminal (Transmit/Receive) with Live Camera and Frame Freeze Capability	$250/mo	$ 9,600
Options		
Hard Copy Printer (Photographic)	$ 30/mo	$ 900
Two-Channel Analog Tape Recorder	$ 40/mo	$ 900
Remote Camera Kit	$ 10/mo	$ 335
Large Auxiliary Television Monitor	$ 10/mo	$ 525
Carrying Tray (Table)	$ 10/mo	$ 400
Dial Telephone with Executive Privacy Feature and Acoustic Coupler	$ 10/mo	$ 525
TOTAL	$360/mo	$13,185

NOTE: These cost data were effective during the time of this study, January 1975 through May 1976.

Table 2. Equipment costs.

2.4 EQUIPMENT OPERATION

The first step in equipment operation was to establish communications with the remote site. If ship-to-ship communications were to be effected, any of the standard operating procedures could be employed. If communications were to be established with a Naval hospital ashore, it was necessary to activate a CSB circuit in the usual manner. DEPCOMOPTEVFORPAC arranged for the use of dedicated frequencies for this purpose. In either case, the transmitting operator informed the remote operator of the intention to transmit video or voice or both. The receive operator then activated the terminal and waited for further communications.

Observing the monitor, the transmitting operator adjusted the zoom lens to view as much of the subject material as desired, and then refocused the camera as needed. If the subject was a document or other motionless object, the transmit button was pressed, and the video sent out over the line in a live or high-resolution format (55 seconds transmit time). If the subject was capable of movement after the camera was set, the frame freeze button was pressed and the stopped-action frame appeared on the monitor. Then the operator pressed transmit, and the picture was sent out with normal resolution (30 seconds transmit time). The operator could transmit any subject material via the frame freeze mode. This was particularly valuable if shorter transmit time was important. At the remote end, the terminal would automatically key to receive the video in the proper resolution format. However, the receiving operator could adjust the monitor for contrast and brightness as one would a home TV.

When the full picture had been received, the system automatically switched back to voice mode. The video would remain on display as long as required, and was erased only for presentation of a succeeding frame. Voice conversation stopped during video transmission, but could continue in the half-duplex mode during the no-video-transmission period, so that the video being viewed could be discussed.

Figure 2 shows a shipboard corpsman using the voice link as he viewed a transmitted picture on the monitor screen.

2.5 TRAINING OF TEST PARTICIPANTS

The four types of participants — physicians, corpsmen, technicians, and communicators — were trained by NOSC personnel for their roles in the operational tests. Training consisted of briefings prior to deployment, demonstrations, on-the-job training with links and terminals operating, and debriefings at appropriate junctures during the test period. Training also covered the purposes of RMDS and the feasibility tests, system and equipment description, operating procedures, test procedures, and adjustment and maintenance.

Figure 2. Corpsman at shipboard RMDS terminal, USS JUNEAU.

SECTION 3

THE TEST PROGRAM

3.1 PARTICIPATING SHIPS AND STATIONS

The fleet support request to DEPCOMOPTEVFORPAC asked for the assignment of test platforms which would operate initially in the Eastern Pacific (EASTPAC) as part of a force or group, and later deploy to the Western Pacific (WESTPAC) as part of the same force or group. An additional stipulation was that of the ships selected, one should be from a large-ship class (CV, CGN, LCC, or LPH) and one from a small-ship class (DDG, DE, or LST). The rationale was that the large ship would be staffed with a physician, whereas the smaller type would not have a physician onboard.

The ships selected as test platforms by DEPCOMOPTEVFORPAC, all from the Amphibious Force of the Pacific Fleet, were:

- USS JUNEAU (LPD-10)
- USS ALAMO (LSD-33)
- USS FORT FISHER (LSD-40)

The medical staff of JUNEAU, as well as FORT FISHER, had a physician assigned as a member of ship's company; ALAMO had no physician assigned. JUNEAU and ALAMO were selected first, and FORT FISHER was added later when it was determined that the three ships would operate in close proximity in WESTPAC.

Besides the three ships, NOSC also equipped two shore stations with the RMDS terminals for participation in the tests. One terminal was placed in the NOSC Bioengineering Laboratory, and the other was placed in the emergency room of the Naval Regional Medical Center (NRMC), San Diego. Inasmuch as NRMC maintains no radio communications equipment of its own, transmission and reception to and from the terminal located in the emergency room was accomplished via land lines (telephone) through the Command Switch Board (CSB) located at the Naval Communications Station (NAVCOMMSTA), San Diego. NAVCOMMSTA San Diego, as well as other NAVCOMMSTAs around the world, is equipped to receive and relay (patch) voice communications via the Automatic Voice Operated Network (AUTOVON) or the Command Switch Board (CSB), formerly known as the Navy Operated Radio and Telephone System (NORATS). The participating stations and interconnecting links are shown in figure 3. Other stations which participated in the test once the ships reached WESTPAC included NAVCOMMSTA Honolulu, NAVCOMMSTA Guam, and NAVCOMMSTA Philippines. These stations were not RMDS-equipped, but were used to relay data from the ships-at-sea to NRMC, San Diego.

3.2 DESCRIPTION OF OPERATIONAL SUITABILITY TESTS

The test plan called for five operational suitability tests; however, one of these, a crypto test, could not be performed as part of this series. (It was possible at a

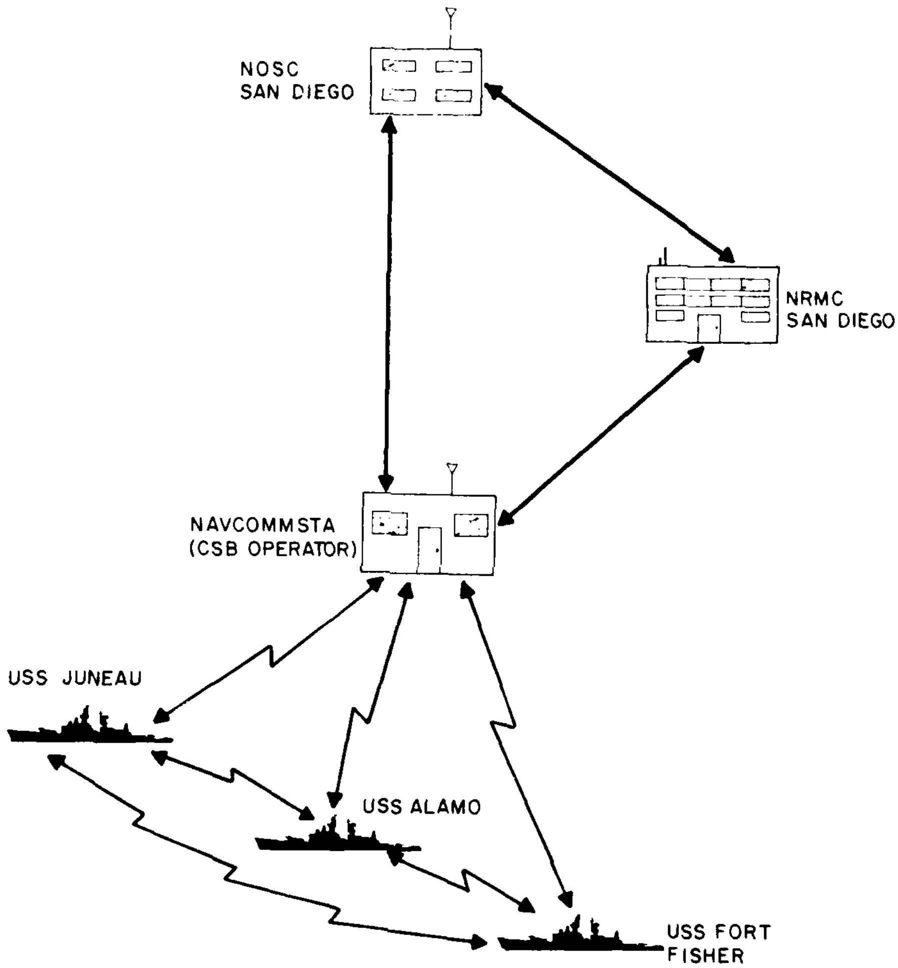


Figure 3. Participating stations and interconnecting links.

later time to run a limited test through crypto equipment; this is described in section 5.1.) The four operational suitability tests which were conducted are described below:

A. Test 0-1: Frame Freeze (FF) Versus Live Transmission

The purpose of this test was to determine which of the two modes of operation, frame freeze (FF) or live, would be most useful for shipboard application.

The test plan called for transmission of 10 images twice (once in the FF mode and once in the live mode), photographing the transmit and receive monitors at various sea states and speeds, and subjective analysis of the photographs to determine mode selection criteria under different conditions. This test used ship-to-ship and ship-to-shore communication networks operating on uhf or hf frequencies, selected by the COMMCEN personnel to afford the best communication link for the particular time of day and for the distance between participants.

B. Test 0-2: Image Quality

The purpose of this test was to determine if the received video information had sufficient quality to permit accurate diagnosis by a qualified physician. The test required four different types of communication links for transmission of visual materials, as follows:

(1) Transmission from a ship without a physician onboard to a ship with a physician onboard.

(2) Transmission from a ship via uhf to another ship. The receiving ship recorded the received data on the analog tape recorder provided, and retransmitted the recorded data to a communications station via hf for entry into CSB and relay to the NRMC, San Diego.

(3) Transmission from each ship directly to a communications station via uhf or hf for entry into CSB and relay to the NRMC, San Diego.

(4) Transmission from each ship to a communication station, ie, NAVCOMMSTA HONO. NAVCOMMSTA HONO either entered the call directly into CSB or relayed it to NAVCOMMSTA, San Diego for further relay to NRMC, San Diego.

C. Test 0-3: Field of View

The purpose of this test was to determine the variation in field of view sizes which would be useful to the physician in getting an overall view of the subject, as well as a close-up of a particular part of the subject, for example an X-ray of an injured limb.

The test plan called for the use of transparent overlays of a two-coordinate grid structure, marked in either inches or centimeters to assist in interpretation. This was found to be of little value, however, and was eliminated. Images ranging in size from 2" by 3" (5.08 cm x 7.62 cm) to 14" by 17" (35.56 cm x 43.18 cm) could be successfully viewed and were used in this test.

D. Test 0-4: Simulated Medical Cases

The purpose of this test was to determine the capability of the RMDS to transmit and display medical data adequate in quality to support diagnosis by the shipboard corpsmen or physician.

This test presented simulated medical cases via the RMDS to participants for diagnosis or consultation. It was conducted using the same four types of communication circuits used in Test 0-2. The data collected were to include the diagnosis reached by the physician, information used in reaching the diagnosis, any additional information the physician felt would have assisted in reaching an accurate diagnosis but not obtainable via RMDS, recommended treatment or disposition, and subjective evaluation by the physician and corpsmen. Similar data were to be collected on any actual medical cases for which RMDS was used during the testing period.

SECTION 4

TEST RESULTS

4.1 SUMMARY

The first test participants to be equipped with the VV-1 videovoice terminal were NOSC and NRMC, San Diego. Testing between these two terminals commenced in January 1975, and continued aperiodically through 19 May 1976. By April 1975, equipment had been installed on JUNEAU and ALAMO. FORT FISHER was equipped by September 1975.

The early phases of testing between NOSC and NRMC were concerned primarily with determining procedures to be followed when establishing communications, with an optimum lighting of data to be transmitted as a video image. As NRMC had no standard Navy communications equipment, all transmissions to and all receptions from the NRMC terminal were effected via telephone patch, the CSB facilities of NAVCOMMSTA San Diego, or AUTOVON. At NOSC, on the other hand, transmission and reception of data were accomplished via hf, uhf, or telephone patch, including AUTOVON, as requested by the test director on any given day. Some transmissions were in the frame freeze (FF) mode and some were in the live mode. In each of the two modes, some difficulty was experienced by transmitting stations in determining the correct lighting to be used on charts, X-rays, graphs, etc., to be imaged for transmission. Front lighting as well as back lighting of X-rays and ECG tracings was attempted, and brightness and contrast adjustments of the image on the transmit monitor were made prior to transmission, in an effort to attain the clearest possible image for transmission. Likewise, the receiving terminal operator was free to adjust the brightness and contrast controls on the receive monitor to obtain a clear picture.

The quality of viewed images, as reported in the test results which follow, represents the subjective judgment of the person who viewed the image. Equipment adjustments at both the transmitting and receiving terminals affected the quality of all images. A worst case for a poor or unsatisfactory quality image can be constructed where:

A. The viewing camera was out of focus.

B. The receive monitor brightness and contrast controls were not properly adjusted.

C. The photographic equipment was set with the improper aperture or shutter speed or the lens was improperly focused.

Note: Adjusting the transmit monitor brightness and contrast controls did not affect the clarity of the transmitted image.

Throughout the remainder of this report, the word "picture" means a video image, whether transmitted, received, or merely displayed by a test participant. The word "photograph" means a photographic reproduction of a picture as it appeared on

either a transmit or a receive monitor. No attempt is made in this report to document every test conducted or attempted by the test participants, or to include all photographs which were taken. Some photos appear in the body of the report, and additional ones are presented in Appendix B. The quality of the photos presented is poor, largely because they are prints taken of polaroid photos of the video image on a cathode ray tube. In other words, they are prints of photos taken of pictures of the transmitted and received images.

4.2 INITIAL TESTING

From January 1975 through May 1975, several hundred pictures were exchanged between NOSC and NRMC. Both FF and live modes were used, and NOSC personnel, alternately, in no rigid, predetermined order, transmitted and received via hf or uhf, or through CSB or telephone patch. When JUNEAU and ALAMO became equipped, they too began participating in the tests.

The first participation by JUNEAU and ALAMO was on 10 April 1975; both hf and uhf testing were performed. Other data during this period, however, are sketchy, as the ships were not required to submit completed data sheets. These early tests were conducted primarily to demonstrate the equipment and to familiarize operating personnel with the various procedures to be used throughout the course of testing. During the initial testing phase, problems were encountered with equipment adjustments and with the hf communications equipment interface. NRMC and NAVCOMMSTA, San Diego also participated in the testing, along with NOSC, JUNEAU, and ALAMO.

A. JUNEAU Data

Records maintained in sick bay by a Chief Hospital Corpsman indicated that 23 receptions and 9 transmissions were attempted, with picture quality as follows:

Received Picture Quality:

1	Good
1	Fair
8	Poor
13	Not Received

Concerning each of the 13 pictures not received, JUNEAU comments were that the experimental RMDS did not drop into the receive mode. All but one of the pictures were received with obvious noise interference.

B. FORT FISHER Data

NOSC records indicated that FORT FISHER attempted 9 transmissions and 23 receptions, with quality as follows:

Received Picture Quality:

5	Poor
2	Merely Reported as Received
16	Not Received

C. Analysis of Combined Data

One photograph from this initial period is shown in figure 4. This is an X-ray of a hand transmitted from the JUNEAU (using hf) on 27 May 1975 to CSB, San Diego, and phone patched to NOSC where the photo was taken.

The data recorded for 17 June 1975 are the first significant amounts collected with a participating ship for which photographic documentation was obtained. On this date, 17 exchanges were made between JUNEAU and NOSC, with 11 transmissions from NOSC to JUNEAU and 6 from JUNEAU to NOSC. JUNEAU data are as reported by them via audio link, as no data sheets or photographs were submitted to NOSC.

Receiving Participant	Subjective Judgment of Quality				
	Excellent	Good	Fair	Poor	Not Received
JUNEAU	3	2	2	2	2
NOSC			4	2	

The experimental RMDS was also used to transmit ECG records over the audio channel, as described in section 2.1. Good results were obtained with these tests as illustrated in figure 5.

4.3 TEST 0-1: FRAME FREEZE/LIVE TRANSMISSION

A. General Results

Test 0-1 was performed to determine which of the two modes of operation, frame freeze (FF) or live, presented the most useful picture on the receive monitor. On 5 December and 8 December 1975, NOSC established communications with NRMC via the CSB and exchanged video data in the FF and live modes. At NOSC, CW interference was experienced during the period on 8 December when three pictures were not received and one was reported as poor.

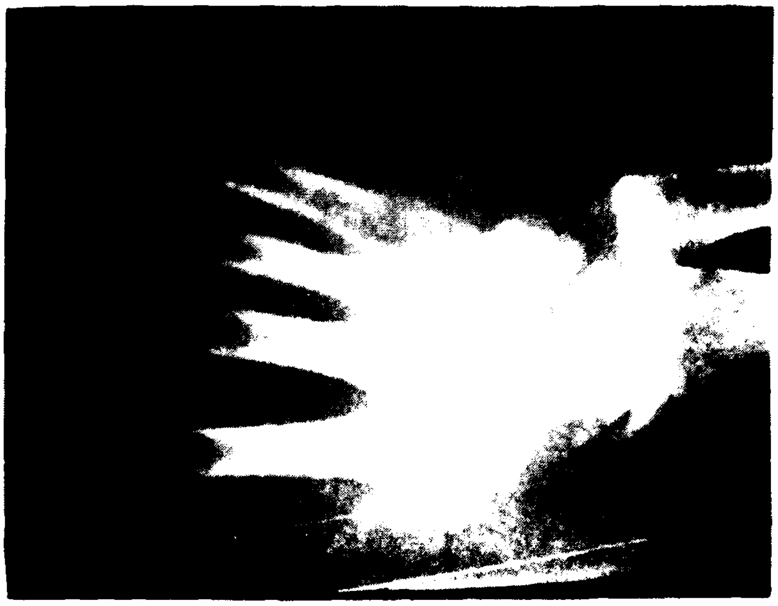
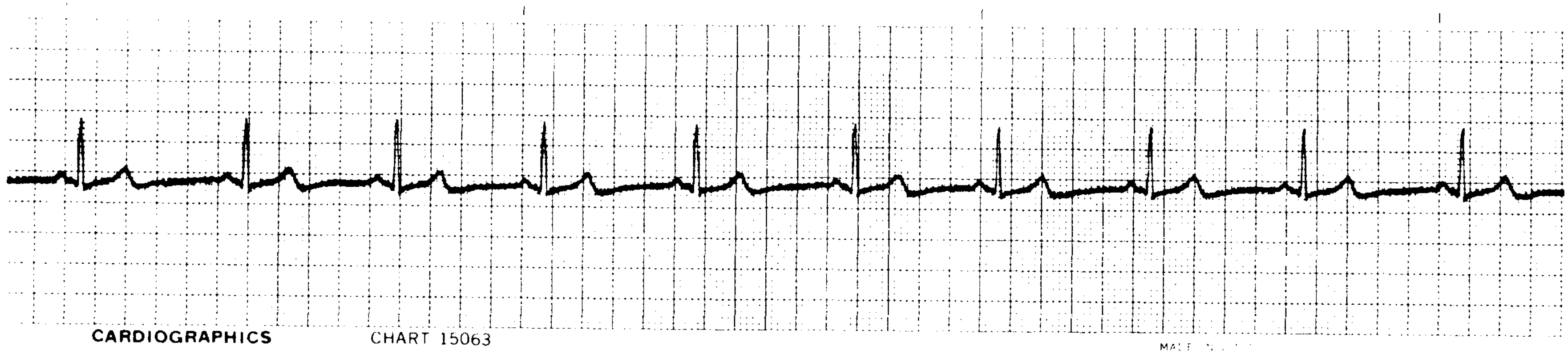
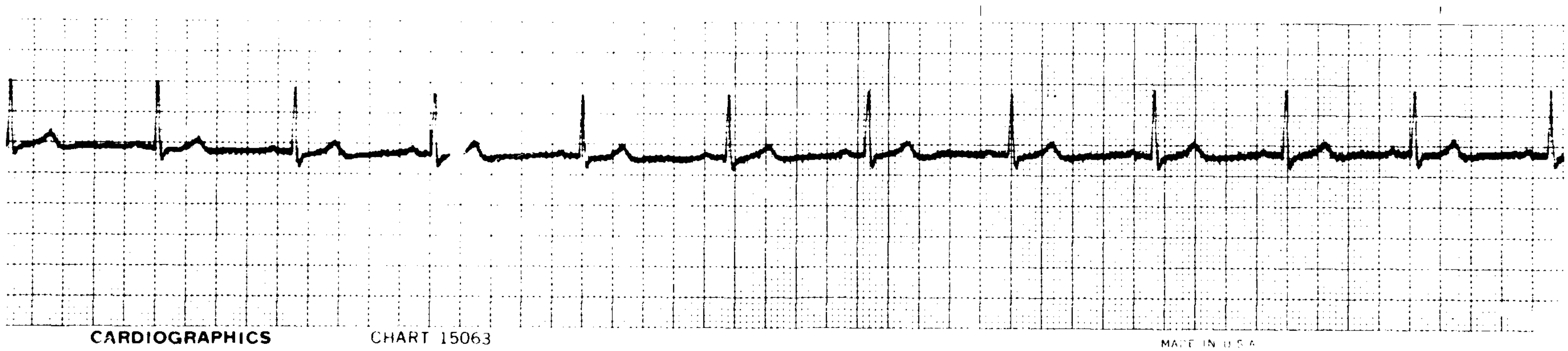


Figure 4. X-ray received at NOSC via RMDS from USS JUNEAU.



5A. From USS FORT FISHER



5B. From USS JUNEAU

Figure 5. Shipboard ECG transmissions over RMDS audio channel as received at NRMC, San Diego.

The only pictures reported as being of excellent quality were those received at NOSC in the FF mode on 5 December. Comparing these data to the rest of the data collected throughout the test series, shows this result to be the exception rather than the rule. It can be assumed, with some justification, that using the telephone lines and the CSB link generally produced better quality pictures than a radio frequency link, regardless of whether FF or live was selected as the mode of operation.

B. Analysis

The success of this test is indicated by results showing that 91 percent of the images received were of good quality in both modes. Less than 9 percent were either poor, not received, or for technical reasons not evaluated. This is an indication that, given a relatively interference-free medium for the exchange of video data, good quality video images can be expected for a high percentage of the time. It was concluded that, depending on the subject matter to be transmitted, the FF mode would be adequate; for example, views of an ECG strip or a skin laceration would be candidates for the FF mode. On the other hand, the resolution provided in the FF mode (only half the resolution of the live mode) was found not to be adequate for certain subject material, such as chest X-rays. Hence, it is concluded that an FF mode with better resolution will be required.

4.4 TEST 0-2: IMAGE QUALITY

The purpose of this test was to determine if the received video picture was of sufficient fidelity to permit accurate diagnosis by a qualified physician.

A. General Results

In January 1976, while JUNEAU and FORT FISHER were operating in company and ALAMO was in port at Subic Bay, P.I., the NOSC test director conducted a series of tests with all ships and NOSC participating. All three ships were in the vicinity of the Philippine Islands. NAVCOMMSTA Philippines (PHIL) participated in the tests to the extent of relaying received signals from the ships to NOSC via AUTOVON to NAVCOMMSTA San Diego, and then via CSB to NOSC. Pictures from NOSC to the ships followed the reverse route, with hf transmission provided by NAVCOMMSTA PHIL. The simplex network was on 4562.5 kHz.

Of the four types of communication circuits proposed for this test, only the ship-to-ship hf circuit and the ship-to-shore hf circuit were attempted. The uhf circuit was not established because the test participants were not all within line-of-sight (LOS) range of NAVCOMMSTA PHIL. Due to the excessively noisy atmospheric conditions which

prevailed throughout this test, it was decided not to have NAVCOMMSTA PHIL attempt to relay received data to NAVCOMMSTA HONO or to NAVCOMMSTA San Diego via hf, but to enter the signals directly to AUTOVON instead.

In an operation of this type, reconstruction of events after the fact is at best tenuous due to the lack of consistency or corroborative records from participants. As an example, during this series of tests, 32 distinct transmissions occurred. However, there is some disagreement as to what ship or station made a specific transmission, and how many transmissions were made by each participant. Of the 32 known transmissions, NOSC reported the number of transmissions by each unit as follows:

- JUNEAU - 11
- FORT FISHER - 9
- ALAMO - 6
- NOSC - 6

The importance of determining which ship or station made a specific transmission during this series of tests is not as critical, in the analytical sense, as the information concerning how that particular transmission was or was not received by those participants reporting it.

B. NOSC Data

NOSC reports 6 transmission attempts and 26 reception attempts by NOSC personnel during this test. Data recorded at NOSC were graded as shown in table 3.

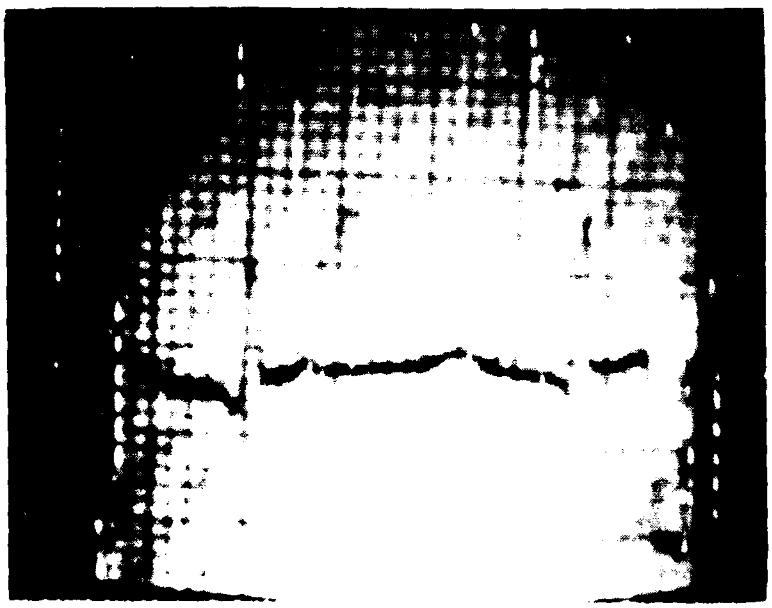
The received signal levels varied from -43.8 dBm to -30.6 dBm. Transmitted signal levels varied from 0 to -5 dBm. The two pictures received at a signal level of -31 dBm were classified as excellent. Those reported as fair were received at signal levels of -37.8 dBm to -32.7 dBm. All others were at or below that level, with noise levels at or exceeding the signal level.

The sample photographs shown in figure 6 were taken at NOSC on 26 January 1976. Figure 6A is a photo of an ECG transmitted from the USS JUNEAU in the South China Sea (using hf) to CSB Naval Communications Station, Philippines. From there it was phone patched via AUTOVON to CSB, San Diego, and on to NOSC. Figure 6B is a photo of an ECG tracing transmitted from the USS FORT FISHER the same day, using the same communication link as was used by JUNEAU and NOSC. It was transmitted 30 minutes before the ECG shown in figure 6A, and shows the problems encountered due to noise interruptions in the hf link. This sort of reception, good one minute and bad the next, is typical of hf communications.

Participant						
Image Quality	NOSC	JUNEAU	FORT FISHER	ALAMO	Total Images	Percentage of Total (%)
Excellent	2	---	---	---	2	2.1
Fair	4	1	---	2	7	7.3
Poor	5	5	7	3	20	20.8
Not Received or Recorded	15	15	16	21	67	69.8
TOTAL	26	21	23	26	96	100.0

Table 3. Test 0-2, received image quality.

6A. From USS JUNEAU



6B. From USS FORT FISHER

Figure 6. ECGs transmitted from ships in South China Sea to NOSC, San Diego.

C. JUNEAU Data

JUNEAU (as recorded by NOSC) attempted 11 transmissions and 21 receptions. The image quality of these 21 receptions is broken out in table 3.

D. FORT FISHER Data

FORT FISHER attempted 9 transmissions and 23 receptions, according to NOSC records. Received image quality is broken out in table 3.

Data Sheet 0-3, submitted by FORT FISHER in support of this test, indicated the first reception they attempted was at 1840Z, 15 minutes after the test was started. The first five pictures had already been transmitted. Transmit and receive signal levels were reported from 1 dBm to -6 dBm. However, according to FORT FISHER, noise levels ranged from -5 dBM to -12 dBm while no transmissions were being attempted by any test participants. Heavy noise caused the FORT FISHER terminal to drop into a false receive mode several times.

The following remarks concerning transmissions received from all participants were submitted by FORT FISHER:

(1) From FORT FISHER - All transmissions from this ship, as monitored off the air, were choppy.

(2) From JUNEAU - Although JUNEAU was copied, the data signals could not be heard. Received signal levels were from -1 dBm to -2 dBm.

(3) From ALAMO - All pictures were somewhat out of focus and "had too much light." All were broken with noise.

(4) From NOSC - Signals from NOSC could be heard, but the terminal did not drop into the receive mode. The dBm range was from -1 to -2. Several signals sounded fast and very high pitched.

E. ALAMO Data

ALAMO (as reported by NOSC) attempted 6 transmissions and 26 receptions; table 3 presents the received image quality recorded during this testing.

ALAMO submitted Data Sheet 0-2 without specific data but with the comment, "Having a lot of interference while sending signal." Similarly, Data Sheet 0-3 simply noted, "All photos taken, both FF and live, did not turn out."

F. Medical Incident

Although not a part of Test 0-2, an actual incident which occurred on 25 November 1975 demonstrated the diagnostic capabilities of the system. A sailor onboard ALAMO sustained a severe, crushing injury to the middle finger of the left hand. As there was no physician aboard ALAMO, the corpsman in charge contacted the physician on JUNEAU, who was in company. JUNEAU's physician requested a picture of the injury using the RMDS terminal. Several pictures were transmitted. On the basis of the received images, the physician determined that a high line transfer of the patient to JUNEAU was not required, thus eliminating the risk of such a transfer to the patient. Secondly, the physician was able to determine that amputation of the finger at the third joint was indicated as the proper treatment under this circumstance. The physician instructed the corpsman in the appropriate techniques to be used in performing the partial amputation. Reproductions of the photographs of pictures received on JUNEAU both before and after the operation are shown in figure 7.

The consulting physician on JUNEAU stated in his report of the incident that the RMDS was definitely beneficial to the patient's welfare. He also stated that he thought dynamic, real-time video information would have been useful during the time he was instructing the corpsman to perform the amputation, but that the present system was quite useful in performing the surgery.

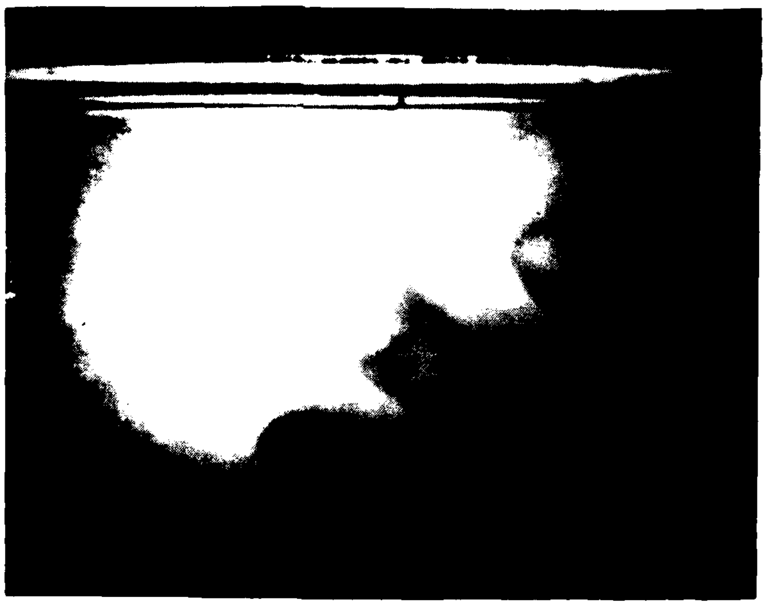
G. Analysis of Combined Data

The results of this testing show that if long-haul video communications are to succeed, the hf spectrum is to be avoided, particularly if one station is undergoing a transition period, ie, day to night or vice versa. The effects of solar transition are detectable in the hf spectrum long before sunrise or sunset. As an example, at the approach of sunrise, the sun's rays strike the ionosphere several hours before local apparent sunrise. This phenomenon causes a warming of the H layers which, in turn, causes ionization. The effects of this ionization are manifested in the hf range as static or noise of varying intensity. This is especially true at the lower end of the hf range used in this test, ie, 4.5 MHz.

Using a cumulative totaling technique, and given that each test participant had from 21 to 26 opportunities to receive a picture, there was a total of 96 reception opportunities. These data are presented in table 3. The best figures available indicate that only 30.2 percent were received at all, and that almost 69 percent of those were of poor quality. Nearly 70 percent of the cumulative total were either not received or not recorded.

It should be noted here that each set of transmitted picture tones was preceded by a code which contained synchronization and picture

7A. Injured finger before amputation.



7B. Finger after partial amputation.

Figure 7. RMDS-transmitted X-rays of finger injury and amputation.

resolution information. When these data were detected at the receive terminal, the code started the receive cycle, which consisted of receiver setup in the proper resolution mode, storage-tube "erase," "write," and "read" cycling; and "start-of-frame" synchronization (sync). When sync tones were missed, ie, not detected by the receive terminals, the video data were not displayed even when the data were sufficient to provide excellent picture quality. This has been demonstrated at NOSC by playing magnetic tape recordings of video data into a receive terminal which was manually activated, vice automatically activated via sync tones. The excellent quality of a few receptions via hf is most reassuring that the system will work well when clear frequencies are available.

4.5 TEST 0-3: FIELD OF VIEW

It was determined early in the testing that pictures ranging in size from 2" by 3" to 14" by 17" could be successfully imaged for transmission by RMDS. Therefore, this was the range in sizes used for this test.

A. General Results

Test 0-3 was conducted between JUNEAU and ALAMO on 24 March 1976 and 3 April 1976. All transmissions were to JUNEAU, as ALAMO RMDS equipment could transmit but not receive. (Upon return to CONUS, it was determined that an open lead in the input side to ALAMO's receive terminal was the probable cause of the malfunction.)

The test on 24 March 1976 was conducted between 1100Z and 1200Z on a frequency of 3211.5 kHz. JUNEAU reported the noise decibel level throughout this test as 0 dB. Of the 11 transmissions from ALAMO, 4 were in the FF mode, and 7 were in the live mode. JUNEAU equipment did not drop into the receive mode for the first reception attempt. On the second attempt, the equipment did set up in the receive mode but no picture was received. The five pictures received in the live mode, as well as the four pictures received in the FF mode, were all reported as poor to very poor quality.

The test on 3 April 1976 was conducted from 1310Z to 1420Z on a frequency of 9408.5 kHz. After the first 20 minutes, the frequency was changed to 3325 kHz. This frequency change does not appear to have had any effect on increasing picture quality.

Three attempts were made to transmit pictures to ALAMO from JUNEAU with no success. Data Sheet 0-2 from JUNEAU contained the comment, "Same old story - we receive ALAMO fine, ALAMO does not drop into receive mode." Data Sheet 0-3, filled out by JUNEAU

medical personnel, reports the 10 reception attempts were all in the live mode.

Received Image Quality:

8	Fair
1	Poor
1	Not Received

The primary problem in this test series on both days, aside from the fact that ALAMO could not receive, was the difficulty encountered by ALAMO personnel in bringing the viewing camera into focus. This particular problem was not reported by any of the other test participants.

B. Analysis

Notwithstanding the obviously out-of-focus photographs, this test is considered to have been a success. However, it does appear that more uniform lighting of images to be transmitted would have enhanced the quality of the received images. Adequate and uniform lighting is a factor requiring more testing in future studies of RMDS.

4.6 TEST 0-4: SIMULATED MEDICAL CASES

In determining the degree of capability of RMDS to provide adequate medical diagnostic assistance to shipboard corpsmen or physicians, these personnel were requested to fill out Data Sheet 0-5. A copy of Data Sheet 0-5, as it appeared in the test plan, is contained in Appendix A.

A. General Results

The small number of 0-5 Data Sheets submitted to NOSC in support of this test was not felt to be statistically significant by the test director. In five of seven cases, the corpsmen who completed the questionnaires were reluctant to give an opinion as to their attitude toward the system, preferring instead the noncommital "neutral" response. The most frequent responses to question 9 regarding data which was not obtainable but of potential value in the diagnosis were: physical examination, patient history, and vital signs.

Data Sheet 0-5 was submitted by the physician on JUNEAU and by the corpsman on ALAMO following the emergency amputation reported in paragraph 4.4. Both felt the system had been beneficial to the patient's welfare and both had a positive attitude toward using it. During post-cruise debriefings of medical personnel who participated in the tests, it was learned that there were five cases of appendicitis

on ALAMO during the course of the cruise. Medical personnel on ALAMO found it most convenient to have a voice terminal immediately available in the sick bay for consultation with a physician.

The corpsmen who filled out Data Sheet 0-5 for this test could have done it more accurately if they had been specifically trained as physician's assistants. Corpsmen who have been so trained have a better idea of what to look for. As an example, one picture of a chest X-ray which was transmitted to JUNEAU was of marginal to poor quality. While the corpsman rated the picture as unusable, the physician was able to diagnose a collapsed lung as the probable cause of the patient's chest pain.

B. Analysis

An insufficient amount of data was gathered during this specific test to form conclusions based solely on these data. However, a sufficient number of good to excellent quality pictures were photographed throughout the series of tests to indicate that many types of diagnoses can be made using the capabilities of the RMDS.

4.7 SYNOPSIS OF DATA

During the conduct of this feasibility study, 289 documented reception attempts were made by NOSC personnel. This number does not include those tests conducted at the outset of the study, as they were primarily for purposes of equipment checkout and personnel training. The data collected by the ships and by NRMC compares quite favorably with the NOSC data.

Analysis of the data recorded at NOSC shows that 42.2 percent of all reception attempts were of usable quality, while 57.8 percent were poor, or not received, or simply not documented. Figure 8 shows reception quality, by percentage, as recorded at NOSC.

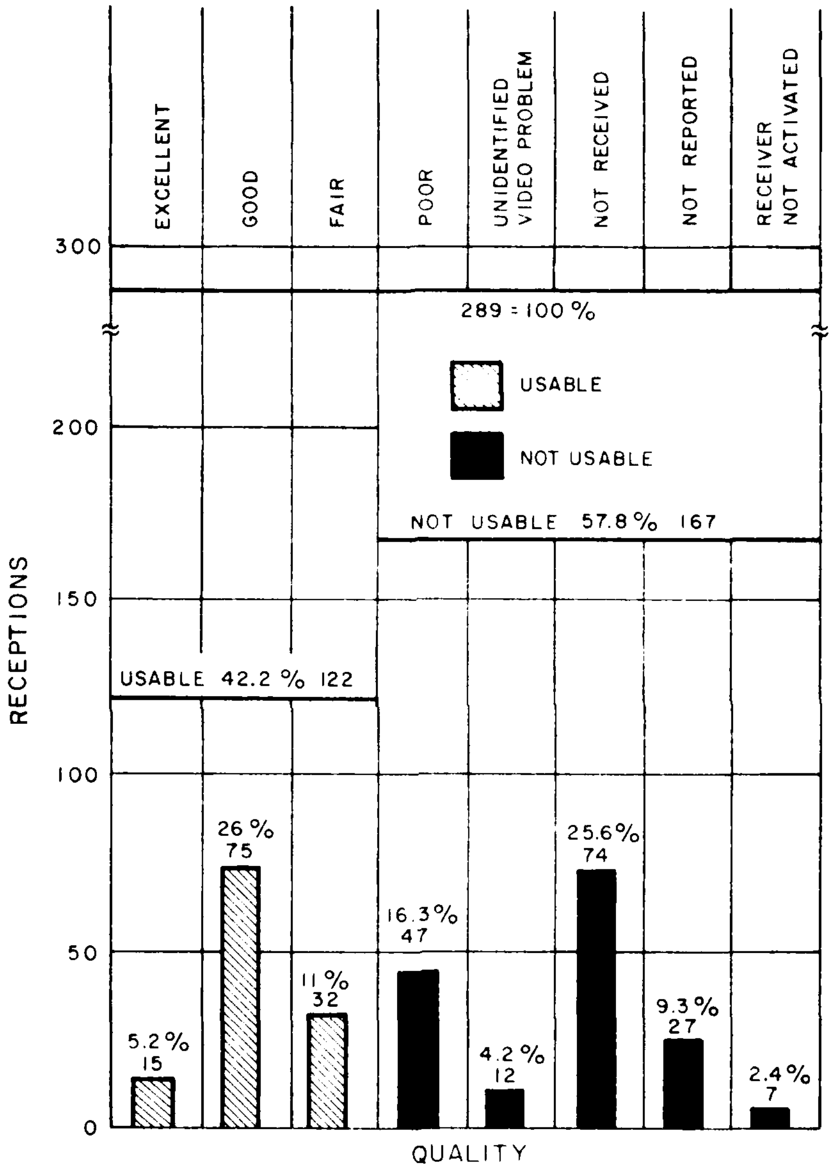


Figure 8. Reception quality as recorded at NOSC.

SECTION 5

SUPPLEMENTAL TESTS

Two tests conducted in addition to the operational tests are described in this section.

5.1 CRYPTO TEST

A. Purpose

This test was conducted to determine the degradation which might result if the RMDS signals were routed through crypto gear as part of the radio communication link. The original intent was to conduct a crypto test as part of the operational tests, but it was not possible to do so. At a later date, however, it was possible to conduct such a test aboard the USS JUNEAU.

B. Test System

This was a very limited test, using recorded inputs to the system aboard the JUNEAU rather than two stations connected by radio link. An HP 3960 instrumentation tape recorder was used to prepare the slow-scan video recordings. These test video tapes were then played back into a KY-8 crypto transmitter which was electrically connected to a KY-8 crypto receiver which, in turn, was connected to a second HP 3960 recorder. The tapes recorded by the second recorder were played back into the JUNEAU's RMDS equipment, and the resulting display was compared with the display when playing the original video tapes.

C. Procedure

Tapes were run with each of the two modes of the KY-8 equipment, diphase and baseband, which are used with uhf and vhf radio channels, respectively. Photographs were taken of the displays for both modes. The photographs were subjectively analyzed to determine if differences existed between the two modes and between each of these and the original image.

D. Results and Conclusions

There was no apparent difference in picture quality between the two operating modes. Both diphase and baseband modes were relatively noise-free, and image quality was judged to be satisfactory in both cases.

5.2 AUDIO-VIDEO LECTURE TEST

A. Purpose

It is expected that the main use of the RMDS for patient diagnosis and treatment might actually require a relatively small amount of time, thereby leaving the system available for other purposes. Accordingly, this test was conducted to determine whether or not the RMDS when installed might be advantageously used on an availability basis for audio-visual lecture purposes, using instructional materials where motion is not essential. Such lecture material could be prepared and used in a closed circuit system, or if communication facilities were available, transmitted either by shore stations or large ships. Although the main lecture use would probably be for medically-related topics, the system conceivably could also be used for lectures unrelated to RMDS as a part of the ship's training program.

B. Test System

This test was conducted with the cooperation of the Technological Institute at Northwestern University. The test facilities included the RMDS facilities at NOSC and Northwestern slow-scan video equipment (RCA's videovoice VV-1, same as used in RMDS) tied together by telephone lines. In one part of the test, Northwestern transmitted to NAVCOMMSTA, San Diego, which relayed the data to NOSC by radio link to simulate transmission to a ship at sea (see figure 9).

C. Procedure

The test material used was a series of slow-scan TV lecture/demonstrations on the Heimlich Maneuver, a first-aid technique for choking victims. The lecture material was presented under two conditions: (1) a single telephone line was used, requiring suppression of voice during actual picture transmission, and (2) two telephone lines were used, allowing simultaneous voice and picture transmission. Two groups of subjects, A and B, were used to balance out the order of the presentation effects. Each group of subjects (5 in A and 6 in B) consisted of members of NOSC engineers and NOSC firemen with paramedic training. Following the lecture presentation on the RMDS monitor and loudspeaker, the subjects were asked to fill out questionnaire forms to obtain a systematic set of data about their observations.

D. Results and Conclusions

The composite results are presented in table 3, which has the same format as the questionnaires which were used. The following relationships derived from an examination of these data are of interest:

(1) Even though all subjects but one knew the technique before the test, all but one (not the same individual) thought they could use the technique better now.

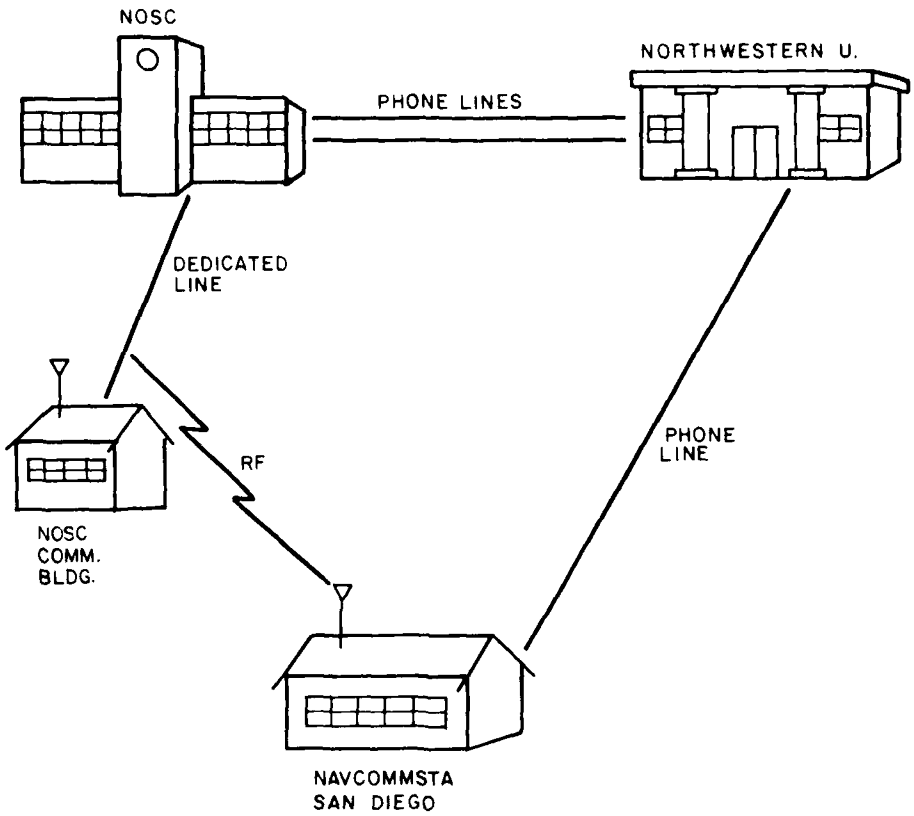


Figure 9. Participating stations and interconnecting links for audio-video lecture test.

QUESTIONS	RESPONSE*					
	Yes		Neutral		No	
	A	B	A	B	A	B
KNEW HOW TO USE TECHNIQUE BEFORE LECTURE	4	6			1	
COULD USE TECHNIQUE BETTER NOW	3	5			1	
FELT CONFIDENT TO TRY TECHNIQUE	4	6	1			
LEARNED AS MUCH AS IF LECTURER WERE IN THE ROOM	3	4	1	2	1	
COULD HAVE LEARNED TECHNIQUE WITH AUDIO ONLY	2				3	
WOULD PAY DOUBLE TO HAVE SIMULTANEOUS AUDIO AND VIDEO	3	4			2	1
WOULD PAY 100 X COST TO HAVE MOTION T.V.		2		1	5	2

*All questions were not answered by each participant.

Table 4. Results of audio-video lecture test.

(2) About two-thirds of the subjects felt they could learn as much using the slow-scan presentation as they could have if a lecturer were in the room.

(3) Most of the subjects felt it was definitely worthwhile to have simultaneous audio and video, but it would not be worthwhile if the price were too high.

(4) Two subjects felt they could have learned the technique with audio only. (They may have been overconfident on this point because they knew how to use the technique before the lecture.)

Tentative conclusions drawn from this test are:

- RMDS has good potential for secondary use as a means of presenting live or recorded audio/video lecture/demonstration material.
- In order to learn how the system can best be used to support training, additional exploratory testing would be required to establish the best procedures and material formats for its use.

SECTION 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Major conclusions from the feasibility tests are:

A. The use of RMDS in an operational environment is a feasible concept and can be a useful aid on ships and at remote shore facilities.

B. Currently designed and available off-the-shelf equipment is not totally adequate for the needs and requirements of a Navy shipboard RMDS. However, the state-of-the-art is such that a system can be designed which will satisfy the requirements and specifications. This system can be designed from existing components with minimal technological development.

C. The RMDS must accommodate transmission of voice, slow-scan video (still pictures), and physiological waveform telemetry. This will enable a consulting physician to make an accurate diagnosis, advise on immediate treatment, and recommend whether or not the patient should be air evacuated or transferred for most emergency cases that might occur aboard ships.

D. The system obtained for the feasibility study used a vacuum electron storage tube to receive, store, and display a video image. Experience with this key component during the feasibility tests showed it to be unreliable. Other means of data storage, such as solid state or magnetic disk, are available and will be used in the next RMDS equipment.

E. The RMDS must be capable of providing a higher video resolution than was available from the system used in the feasibility tests. Although the video resolution was sufficient for many of the images transmitted during the tests, it was not sufficient for an accurate diagnosis for several types of X-rays.

F. A frame snatch (or frame freeze) capability will be required. This will be necessary in order to eliminate relative movement (caused either by the ship or a patient) between the camera and subject during a video transmission. In addition, the RMDS must be capable of the same high video resolution when utilizing the frame freeze mode.

G. Analog video signals in the 3 kHz bandwidth are highly susceptible to the vagaries of the hf communication spectrum. It is expected that digital transmission with error detection and correction techniques will improve video transmissions using the hf spectrum. Also, the use of a satellite relay will provide a better communication link.

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H. Standardized communication procedures for relay patched through shipboard radio rooms and Navy communications stations will be required to maintain proper signal level strengths and signal-to-noise ratios.

I. RMDS can be used to transmit ECG data either graphically or as signal information for strip chart plotting at the receiving station.

J. If it is necessary to route RMDS data through communication facilities with crypto equipment, this can be done without significant impairment to the received images.

K. RMDS can advantageously be utilized for training purposes to present audio-video lecture material where still frame sequences are adequate for instruction.

6.2 DESIGN RECOMMENDATIONS

A. Data Transmission

(1) The system should be capable of analog data transmission and digital data transmission compatible with variable data rate modems: 2400, 4800, or 9600 bits/sec (and possibly even up to 48k bits/sec).

(2) Direct transmission of physiological waveforms such as ECGs, with an interface to a strip chart recorder, and pulmonary-heart sounds.

(3) Transmission of data from either a frame storage or by direct scanning of the subject.

(4) Variable control of digital quantification resulting in variable resolution, and, hence, variable time for transmission.

(5) Automatic and manual data receive modes.

(6) Voice transmission (when video or physiological data is not being transmitted), including loudspeakers with volume control and push-to-talk microphones (eg, a foot control pedal), as well as a standard phone unit. Also, simultaneous voice and data transmission should be considered.

B. Storage and Recording

(1) Video data storage using solid state or shipboard compatible magnetic disk.

(2) Multiple frame storage and recall for hospital units, with possible simultaneous viewing of several images.

(3) Hard-copy recording of video image.

(4) Magnetic tape recording for both video and audio, with capability of playing back video images at highest compatible data rate.

C. Camera and Monitors

(1) The camera should be capable of operating in a vertical or horizontal position. The usual operational position is vertical, to view material which is in a horizontal position.

(2) The camera should be detachable, with a cable to operate remotely from the unit (eg, up to 25 feet).

(3) A monitor should be available to view images either from the camera or from stored video data.

(4) Provide for additional remote monitors as desired. NOTE: This requirement is different from B(2).

(5) Electrically controlled zoom lens, with the control away from the camera view path.

(6) Automatic iris and gain control on the camera, as well as manual controls away from the camera view path.

(7) Electrical focus, having some quantitative indicator with control away from the camera view path.

(8) Camera should be capable of operation over a large dynamic light range, and capable of operation in dimly lit environments.

D. X-Ray Light Box

An X-ray light box (flush with desk top) with a fixture for easy attachment of films, tracings, etc., should be provided.

E. Illumination

A variable light control for an indirect, uniform light source from above, and separate from X-ray light source, should be provided.

6.3 RECOMMENDATIONS ON FURTHER DEVELOPMENT

The Bioengineering Branch of the Naval Ocean Systems Center recommended that further development of the Remote Medical Diagnosis System be pursued. Specifically, it was recommended that the following tasks be completed during the next phase of research and development:

A. System Specifications

Refine the preliminary system specifications and determine items such as:

(1) The requirements for spatial and gray level resolution, dynamic range, and noise levels.

(2) Suitable data compression methods for RMDS and the effects on image quality.

(3) The requirements for physiological waveform monitoring instrumentation.

B. Simultaneous Voice and Data

Investigate the feasibility of simultaneous transmission of voice and data (either video or physiological waveforms). Such a network would require the use of two transmitter/receivers, and would permit uninterrupted voice communications, especially during long transmission times that will be required for high-resolution video via the digital mode.

C. Further Tests

(1) Conduct tests using a system capable of transmitting data in either a digital or analog mode.

(2) Conduct shipboard tests using a digital data transmission mode via satellite channel.

D. Applied Research

Investigate the feasibility and value of incorporating the following features in RMDS:

(1) Electronic stethoscope.

(2) Variable control of the range of gray scale to be emphasized, with results shown on own monitor before transmission (image enhancement).

(3) Edge enhancement.

(4) Alphanumeric keyboard entry.

(5) Microscope/camera interface for slide transmission.

(6) Light cursor or pointer for identifying specific area in video image.

(7) Microprocessor for routine calculations of medical data.

Most of these recommendations have been investigated and completed during the development and testing of the Advanced Development Model (ADM) of the RMDS. These results will be reported in later documentation.

APPENDIX A

DATA SHEETS

This appendix contains blank copies of the data sheets used during the operational suitability tests. The instructions on the sheets were supplemented by oral instructions presented in briefings by the DEPCOMOPTEVFORPAC Project Officer and NOSC test director prior to starting the tests.

PROJECT X/S66

Data Sheet 0-1

This data sheet will be filled out by medical personnel for all tests. Fill out only the applicable portions and attach to other data sheets completed for each test. Include under "Remarks" any comments you feel are pertinent to the test being conducted.

1. Date ______________; Time ______________.

2. Ship/Station ______________________________.

3. Operator Name ______________; Rank/Rate ______________.

4. Transmit/Receive (circle one).

5. Number of Participating Units ____________.

6. Continuity ______________________________

____

7. Time Required to Complete Communication Link Between Yourself and Consulting Physician. ______________________________

8. Number of Aborted Attempts Before This Transmission/Reception.

9. Remarks ______________________________

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PROJECT X/S66

Data Sheet 0-2

This data sheet will be filled out for all tests by communciations personnel at Radio Central, aboard participating ships, and at NAVCOMMSTA, San Diego, for all ship-to-shore tests. Complete all applicable portions and submit to medical personnel to be attached to other data sheets completed for each test. Include under "Remarks" any comments you feel are pertinent to the test being conducted, e.g., "signal level too low to be received by RMDS equipment," or "interruptions in signal."

1. Date ______________________.

2. Ship/Station ______________________________.

3. Operator Name ______________________; Rank/Rate ________.

4. Frequency: Send ______________; Receive ______________.

(If changed during testing, note new frequency.)

5. Number of Participating Units ______________________________.

6. Continuity ______________________________________.

Data Sheet 0-2
Page 1 of 2

7. Video Transmission (Tx)/Reception (Rx). If additional space is needed, complete on another sheet.

Time	F/F or Live	Tx or Rx	dB Level	Signal Quality	Remarks

8. Range of dB Level During Voice Communications ________________.

9. Remarks ____

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Data Sheet 0-2
Page 2 of 2

PROJECT X/S66

Data Sheet 0-3

This data sheet is to be filled out by medical personnel for Test 0-1. Identify each photograph numerically (1, 2, 3, ...) and list below in Item 4; use an additional sheet if needed. All Data Sheets 0-3 completed during a single Test 0-1 are to have one Data Sheet 0-1 completed and attached to them.

1. Date ____________________.

2. Ship's Speed ____________________.

3. Sea State ____________________.

4. Video Transmissions (Tx)/Receptions (Rx)

Number	Time	F/F or Live	Tx or Rx	Usefulness (E/G/F/P)* (Consulting Physician Only)
______	______	__________	________	________________________
______	______	__________	________	________________________
______	______	__________	________	________________________
______	______	__________	________	________________________
______	______	__________	________	________________________
______	______	__________	________	________________________
______	______	__________	________	________________________
______	______	__________	________	________________________

*E = Excellent; G = Good to above average; F = Fair to moderate; and P = Poor or of no use.

5. Remarks ____

____

____

PROJECT X/S66

Data Sheet 0-4

This data sheet will be filled out for Tests 0-2 and 0-3. Fill out only the applicable portions. Include under "Remarks" any comments you feel are pertinent to the test being conducted. All Data Sheets 0-4 completed during a single test (0-2 or 0-3) are to have one Data Sheet 0-1 completed and attached to them.

1. Date ______________________; Time ______________________.

2. Ship/Station ____.

3. Medical Case ID Number ______________________________________.

4. Description (e.g., X-ray, ECG) ________________________________.

5. Number of Transmission/Receptions ____________________________.

6. (Test 0-3) Subject Area Viewed:

	1	2	3	4	5
F/F or Live	___	___	___	___	___
Dimensions of Area	___	___	___	___	___
Focal Length of Zoom Lens (Transmit Station Only)	___	___	___	___	___
Clarity (E/G/F/P)* (Consulting Physician Only)	___	___	___	___	___
Usefulness (E/G/F/P)* (Consulting Physician Only)	___	___	___	___	___

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*E = Excellent: G = Good to above average; F = Fair to moderate; P = Poor or of no use.

Data Sheet 0-4
Page 1 of 2

7. Number of Video Transmissions Which Were Unusable ______________________.

8. Diagnosis ____

____

9. Consulting Physician (Name and Rank) ______________________.

10. Remarks ____

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Data Sheet 0-4
Page 2 of 2

PROJECT X/S66

Data Sheet 0-5

This data sheet will be filled out for Test 0-4 and any actual medical cases presented via RMDS (for actual medical cases, complete Data Sheet 0-6 when feasible). This data sheet is to be completed by both the consulting physician and the attending physician or corpsman; fill out only the applicable portions. Include under "Remarks" any comments you feel are pertinent to the test being conducted. All Data Sheets 0-5 completed during one Test 0-4 period are to have one Data Sheet 0-1 completed and attached to them.

1. Date ____________; Time In ____________; Time Out ______________.
2. Ship/Station ____.
3. Physician/Corpsman: Name ________________; Rank/Rate __________.
4. Medical Case ID Number ____________________________.
5. At this visit, what is the patient's most urgent medical problem (including cause if relevant)? ____

____

____

____

____

____

6. List any other coexisting diagnoses ____________________________

____

____

____

Data Sheet 0-5
Page 1 of 3

7. Your confidence in recognizing the patient's medical problem (diagnostic accuracy) with respect to providing relevant treatment (effective management). Check one:

Completely sure	95-100%	chance you're right	________
Quite sure	75-94%	chance you're right	________
More sure than not	50-74%	chance you're right	________
Unsure	25-49%	chance you're right	________
In the dark	0-24%	chance you're right	________

8. List symptoms and signs used as the basis for your diagnoses:

a) ________________

b) ________________

c) ________________

d) ________________

e) ________________

9. List additional information you would like to have had but could not obtain:

a) ________________

b) ________________

c) ________________

10. Did any of the following restrict your ability to diagnose the problem? Check where applicable:

Lack of Touch	essential ______;	useful ______.
Lack of Dynamic Video (Motion)	essential ______;	useful ______.

Data Sheet 0-5
Page 2 of 3

Lack of Color Video essential ______; useful ______.

Lack of Instrumentation essential ______; useful ______.

Lack of Mobility of Equipment essential ______; useful ______.

Other: ____________ essential ______; useful ______.

11. What would your recommended treatment for the patient be? ____________

____

____

____

12. Do you feel that the system used restricted your ability to make an accurate diagnosis? Check one:

yes	probably	don't know	unlikely	no
____	____	____	____	____

13. Do you feel that the system used was beneficial to the patient's welfare?

yes	probably	don't know	unlikely	no
____	____	____	____	____

14. What is your present attitude toward the system just used? Check one:

strongly positive	positive	neutral	negative	strongly negative
____	____	____	____	____

15. Please record any additional comments you might have on the diagnostic process just experienced ______________________________

____

____

Data Sheet 0-5
Page 3 of 3

PROJECT X/S66

Data Sheet 0-6

This data sheet will be filled out by the patient (if feasible) in all actual medical cases presented via the RMDS. This data sheet will be attached to the corresponding Data Sheet 0-5.

1. Date ______________________.

2. Patient Number ______________________.

3. What do you think the attending doctor/corpsman believes is your most urgent medical problem? ____

____

____

____

4. Do you feel that the attending doctor/corpsman was able to make a complete diagnosis and recommend treatment without the use of the RMDS? Check one:

yes	probably	don't know	unlikely	no
______	______	______	______	______

If not, why? ____.

5. Do you feel the consulting physician was able to make a proper diagnosis? Check one:

yes	probably	don't know	unlikely	no
______	______	______	______	______

If not, why? ____

Data Sheet 0-6
Page 1 of 2

6. What is your present attitude toward the system just used for consulting with another physician? Check one:

strongly positive	positive	neutral	negative	strongly negative
______	______	______	______	______

7. Please record any additional comments you might have on the diagnostic process just experienced: ____

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Data Sheet 0-6
Page 2 of 2

APPENDIX B

ADDITIONAL PHOTOGRAPHS OF TRANSMITTED AND RECEIVED IMAGES

This appendix contains reproductions of photographs taken of transmit and receive monitors. The quality of the pictures is poor, largely because they are photographs taken of polaroid pictures of the video image on a cathode ray tube. In other words, they are prints of pictures of the transmitted and received images.

Figures B1 and B2 compare transmitted and received images of a chest X-ray sent from JUNEAU to NOSC on 15 May 1975. Transmission was via uhf, in the live mode. Figures B3 and B4 also illustrate transmitted and received images in the mode described above; this time, the transmitted image is that of a resolution test pattern. Figures B5 and B6 also show the resolution test pattern, again from JUNEAU to NOSC on 15 May 1975 via uhf; here, the frame freeze mode was employed.

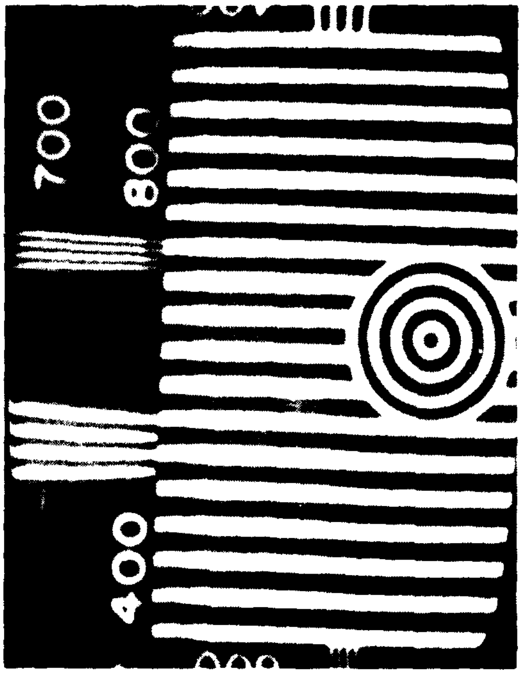
The images shown in figures B7, B8 and B9 have been transmitted from JUNEAU to NAVCOMMSTA San Diego via uhf, and then to NOSC via land line, 15 May 1975. Figures B7 and B8 compare transmitted images in the live and freeze frame modes, respectively; Figures B8 and B9 contrast the transmitted and received images in the frame freeze mode.

ECG tracings were transmitted from NOSC to NAVCOMMSTA San Diego, then routed by land line to NRMC San Diego, 11 February 1975. Figure B10 shows the received image from an hf link, while figure B11 illustrates the image received via uhf transmission.

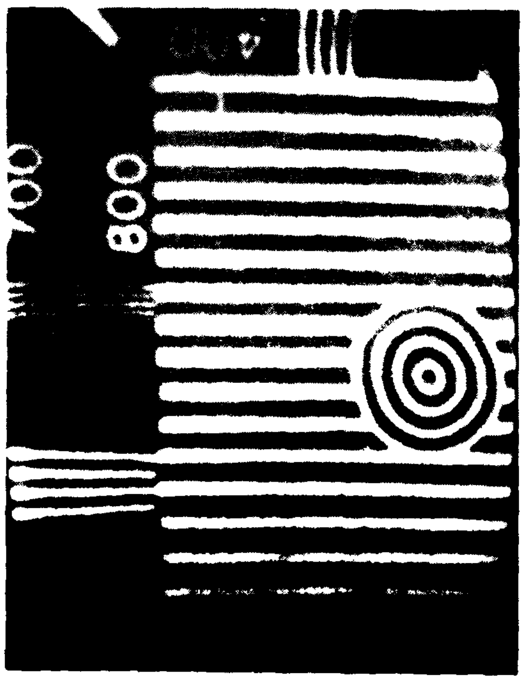
Figure B12 shows the received image of an X-ray sent via land line from NOSC to NRMC San Diego, 11 February 1975. Figure B13 records the received image of the same X-ray, this time transmitted via hf link. The wavy lines in this figure illustrate the effects of noise interference in the hf spectrum.

B1. Transmitted image, from JUNEAU to NOSC, uhf, live, 15 May 1975.

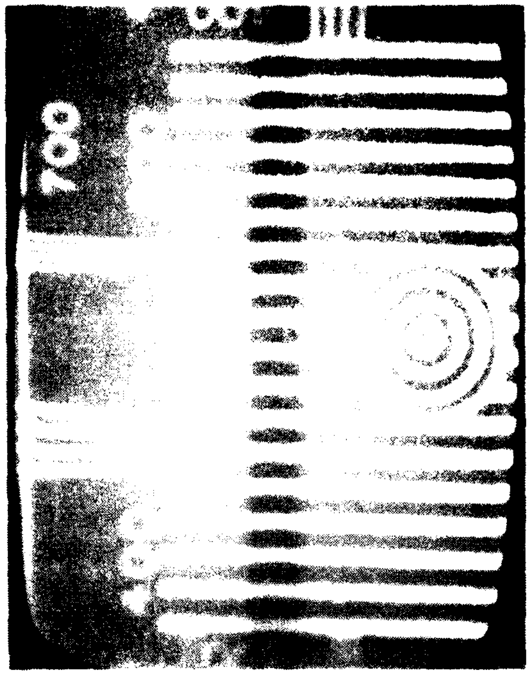
B2. Received image, from JUNEAU to NOSC, uhf, live, 15 May 1975.



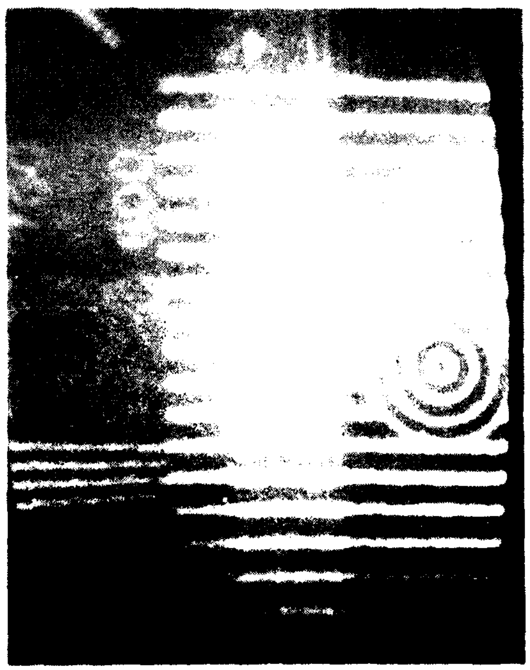
B3. Transmitted image, from JUNEAU to NOSC, uhf, live, 15 May 1975.



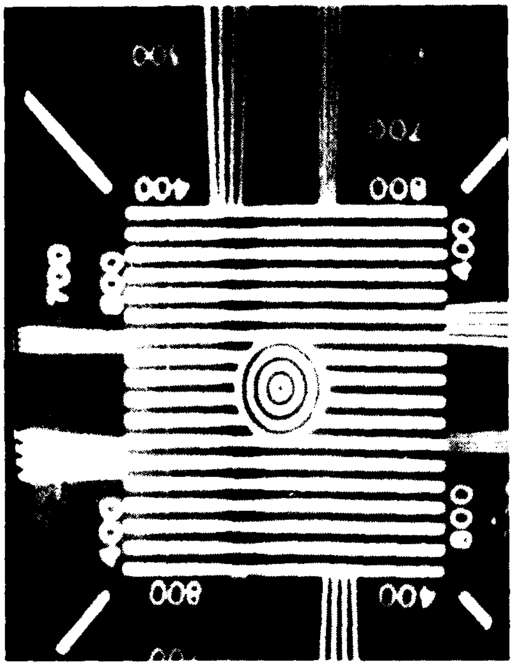
B4. Received image, from JUNEAU to NOSC, uhf, live, 15 May 1975.



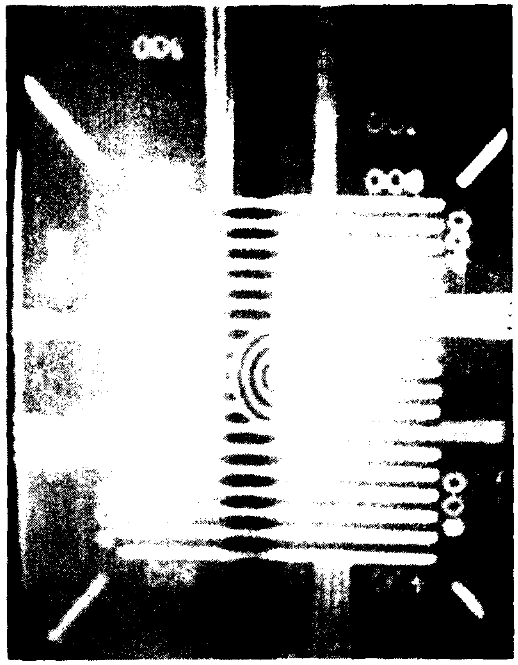
B5. Transmitted image, from JUNEAU to NOSC, uhf, frame freeze, 15 May 1975.



B6. Received image, from JUNEAU to NOSC, uhf, frame freeze, 15 May 1975.



B7.



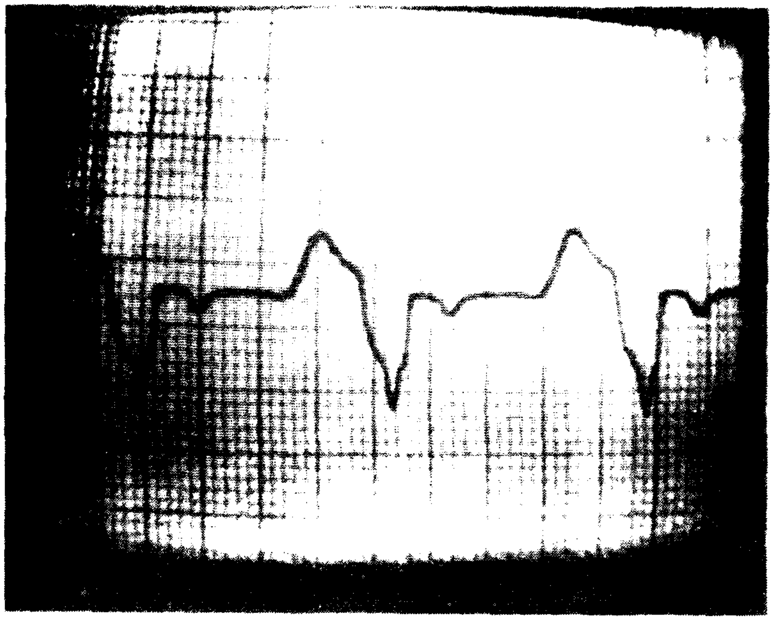
B8.

B7. Transmitted image, from JUNEAU to NAVCOMMSTA via uhf, to NOSC via land line, live, 15 May 1975.

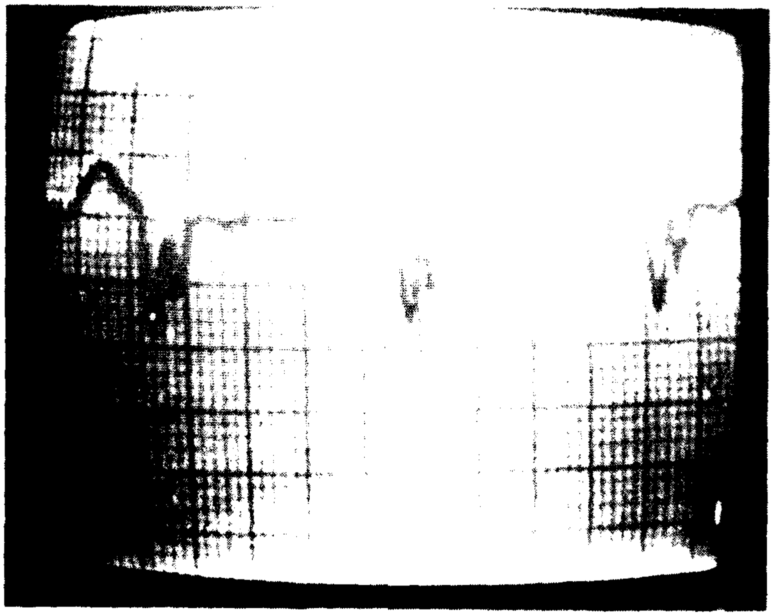
B8. Transmitted image, from JUNEAU to NAVCOMMSTA via uhf, to NOSC via land line, frame freeze, 15 May 1975.

B9. Received image, from JUNEAU to NAVCOMMSTA via uhf, to NOSC via land line, frame freeze, 15 May 1975.

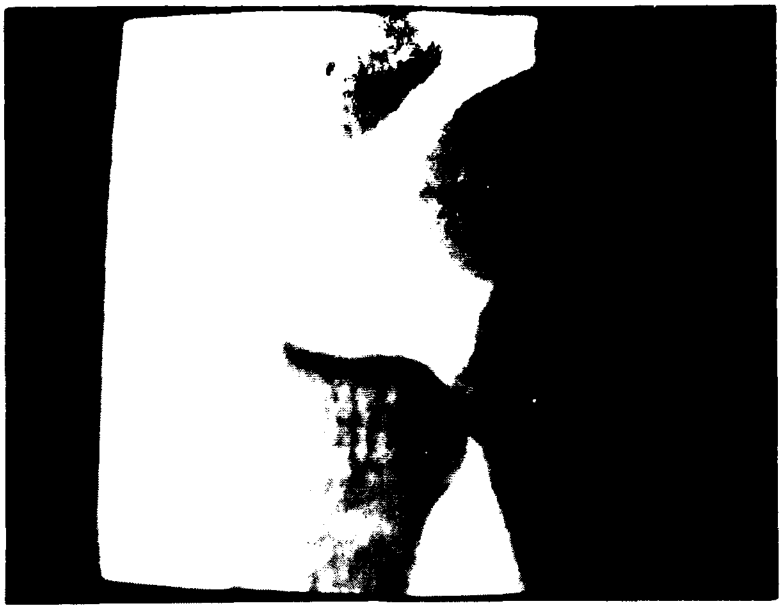
B9.



B10. Received image, from NOSC to NAVCOMMSTA via hf, to NRMC via land line, 11 February 1975.



B11. Received image, from NOSC to NAVCOMMSTA via uhf, to NRMC via land line, 11 February 1975.



B12. Received image, from NOSC to NRMC, land line, 11 February 1975.

B13. Received image, from NOSC to NRMC, hf, 11 February 1975.

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